

Cloudy Radiative Transfer for AIRS

Comparisons to CM2 (GFDL) and ECMWF

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Cloudy RTA

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Overview

RTA Codes

Closure with L2
Clouds

ECMWF
Comparisons

Cirrus
Retrievals

- 1 Summary of scattering radiative transfer code (RTA) developments
- 2 Cirrus retrievals (just a little)
- 3 Comparison of fast scattering RTA calculations using ECMWF cloud fields to observations (first use of ACDS)
- 4 Fast scattering RTA calculation using GFDL CM2 model and comparison to observations and ECMWF

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- AIRS has significant cirrus information, like to retrieve it in V6. Combine with Calipso for improved retrievals?
- This cirrus information might be important for improving the AIRS OLR product. (Important topic with NPOESS, CERES issues).
- Test closure of L2 clouds products with RTA that can include clouds
- Same scattering RTA being used extensively for AIRS dust retrievals (see talk by Breno Imbiriba of our group using Calipso)
- Validation of scattering RTA quite difficult, depends on science goals
- Climate Studies
 - Retrievals very complicated.
 - Climate via radiance monitoring; use sample scattering RTA calculations to understand. (Goody and Haskins.)
 - Compare climate model (and weather model/mesoscale model) output to AIRS observations via scattering RTA.

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- Speed very important, DISORT too slow
- Sergio DeSouza-Machado developed kTwoStream at UMBC to give us expertise. Also implemented RTSPEC (Frank Evans, Univ. Colorado, but no downwelling solar.)
- Weather and climate models have “continuous” clouds. Need “100-layer” scattering RTA?
- *Maybe* kTwoStream too hard to adapt to 100 layers? So, tried very simple and fast code (PCLSAM).
- **But** so far found 2-layer scattering code may be good enough *if* translate “continous” cloud parameters to 2-layer (ice/water, or water/dust) scattering profile.
- Probably always use 2-layer code for retrievals.
- And “100-layer” code for model comparisons?
- Accuracy requirements hard to assess
- SARTA has kTwoStream (2-layers) and PCLSAM (100-layers) now.
- kCARTA has kTwoStream (2-layers), PCLSAM (100-layers), RTSPEC (2-layers), and DISTORT

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- Now have multi-layer PCLSAM scattering in SARTA and kCARTA
- More than one cloud type (Combine scattering parameters using weighted average as per Z.Sun and K. Shine, QJRMS, 1994)
- Can mix “black” clouds (AIRS retrievals) with other multi-layer clouds
- Code to input ECMWF and CM2 (Princeton GFDL) ice and water cloud fields
- Ice: Use Anthony Baran's ice aggregate scattering parameters ($Deff = 40\mu m$, can be fit in retrievals).
- Water: use Mie scattering codes ($Deff = 20\mu m$)

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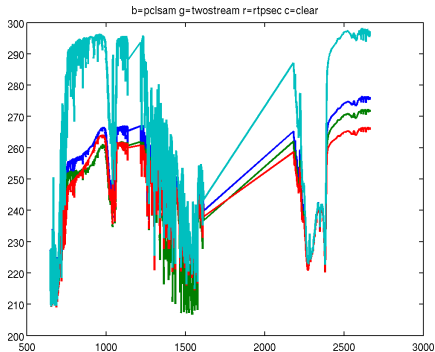
- SARTA started out with “kTwoStream” using 2 scattering slabs;
- Now implemented PCLSAM: “Parameterization for Cloud Longwave Scattering for Use in Atmospheric Models” Ming-Dah Chou, Kyu-Tae Lee, Si-Chee Tsay, and Qiang Fu (J. Climate, v12, pgs 159-169 (1999))
- Parameterizes scattering effects by re-scaling optical depth
- Result is a very fast scattering code that mimics the clear sky algorithm in structure
- Simplicity lends itself to use in longwave scattering retrievals
- Absolute errors on the order of 10%. A problem?

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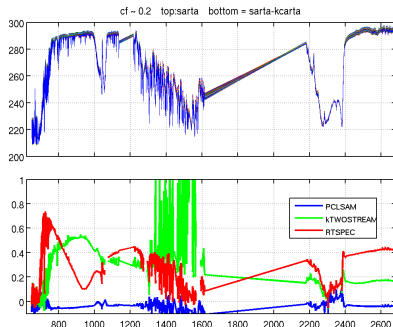
- CM2 (Princeton GFDL) 1996-2000 model data, monthly averages ± 30 deg. lat.
- Reduced cloud profiles to 1 water and 1 ice slab
- Cloud fractions = 1 to emphasize clouds (model avg ~ 0.2)
- RTSPEC is accurate to ~ 1 K for “thicker” clouds via comparisons to DISORT

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- Same as previous slide (CM2) showing only biases
- **BUT** now cloud fraction ~ 0.2
- PCLSAM 100 layer and two-slab models agree very well

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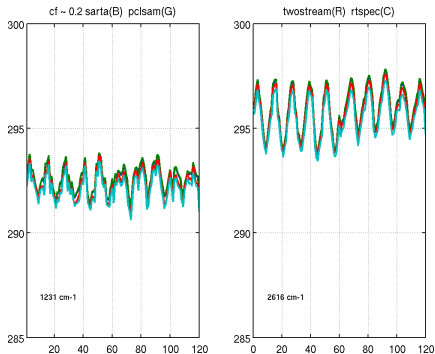
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- Left: 1231 cm⁻¹, Right: 2616 cm⁻¹
- PCLSAM (green); Two-stream (red); RTSPEX (cyan)
- 1:60 = 0-30S, 61:120 = 0:30N
- One slab (for water) and one slab (for ice)
- Cloud fractions $\simeq 0.2$

- How well can SARTA match L1b radiances using L2 cloud retrievals?
- SARTA can include two clouds at different altitudes, each with an associated cloud fraction
- Cloud emissivity set to unity
- Cloud fraction, altitude and atmospheric state from V5 L2 retrievals, Version 5.0.3 (so evidently bad ozone)
- Statistics are for a full day, 2005.10.07
- Only included FOVs with `Qual.Cloud_OLR == 0` & `Qual.Temp_Profile_Bot = 0`
- Calculations match at 800 cm^{-1} and below, as expected, but not in windows.

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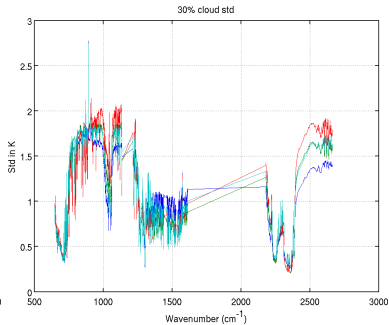
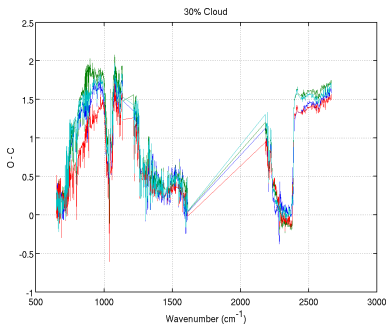
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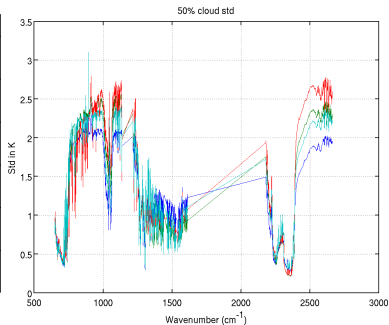
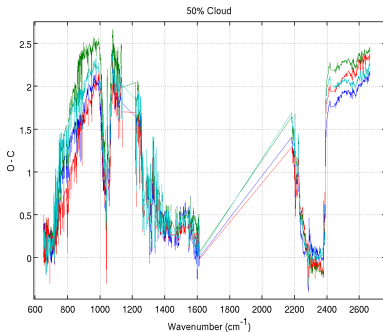
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- ECMWF analysis/forecast contains very complete cloud information
- Accuracy of these model fields appears to be of high interest
- Matched ECMWF to AIRS Climate Data Set (ACDS) random FOV selection for Sept. 2003 - August 2005.
- Computed all channel $B(T)$'s using SARTA/PCLSAM using ECMWF cloud information
- Analysis in progress, mostly comparing observed to computed PDF's of 1231 cm^{-1} $B(T)$'s (histograms).

100-Layer RTA vs 2-slab RTA for 1 day

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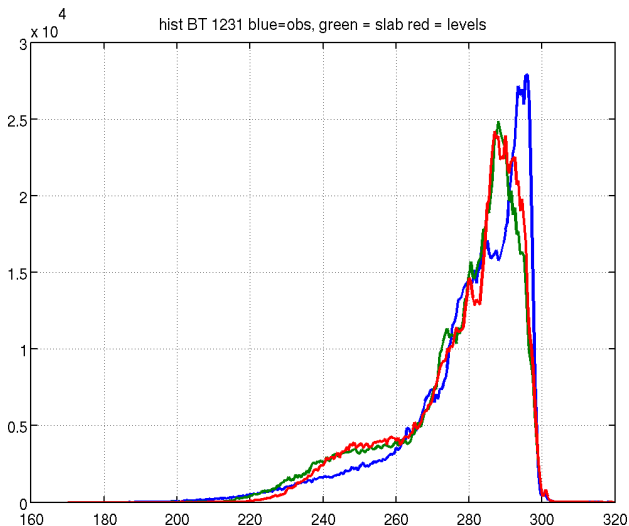
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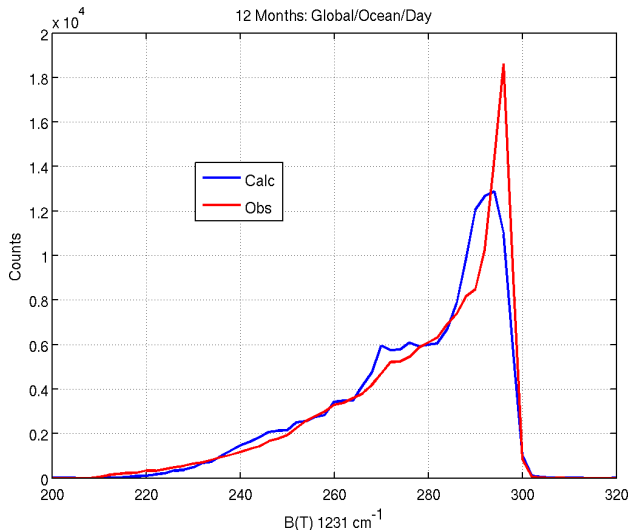
PDF's for 1231 cm^{-1} , Aug. 2003 - July 2004 Global Day Ocean

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PDF's for 1231 cm^{-1} , Aug. 2003 - July 2004

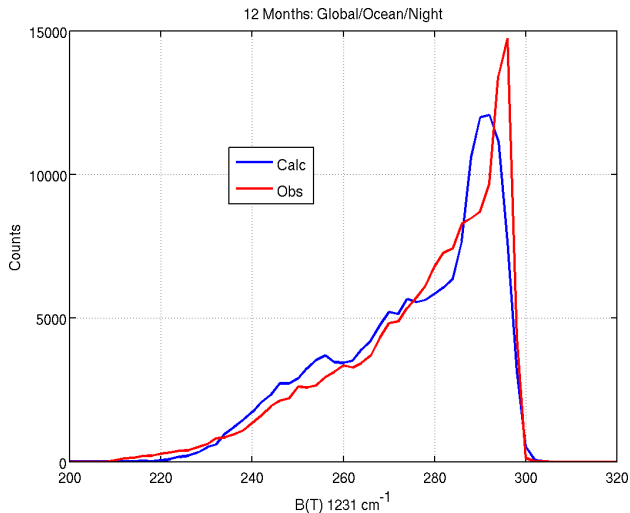
Global Night Ocean

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PDF's for 1231 cm^{-1} , Aug. 2003 - July 2004

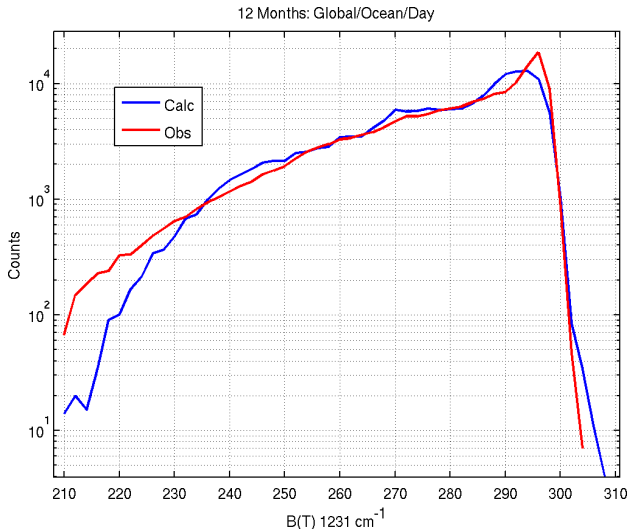
Global Day Ocean Log Scale

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PDF's for 1231 cm^{-1} , Aug. 2003 - July 2004

0-30 Deg. Day Ocean

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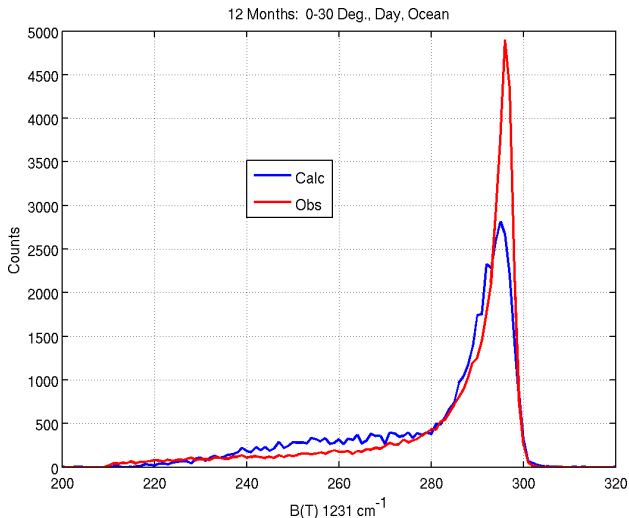
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PDF's for 1231 cm^{-1} , Aug. 2003 - July 2004 0-30 Deg. Night Ocean

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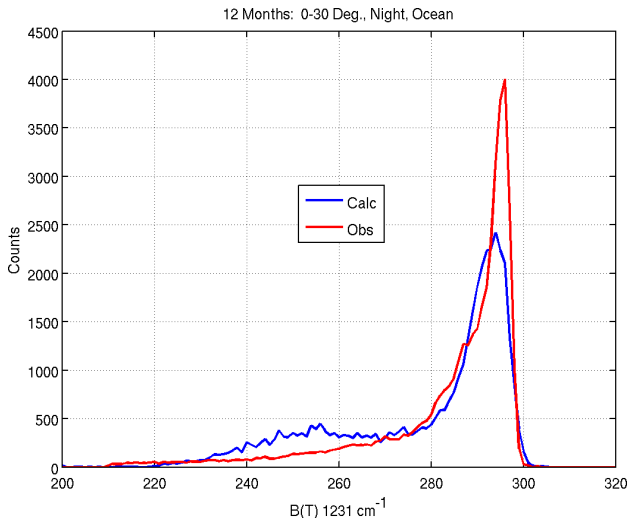
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PDF's for 1231 cm^{-1} , Aug. 2003 - July 2004 0-30 Deg. Night Land

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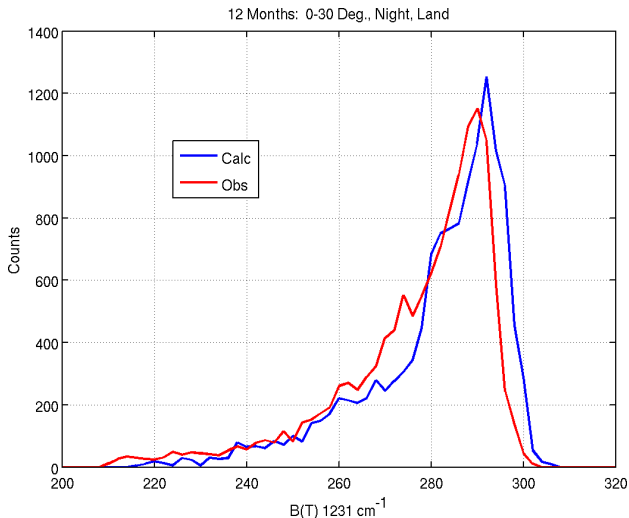
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PDF's for 1231 cm^{-1} , Aug. 2003 - July 2004

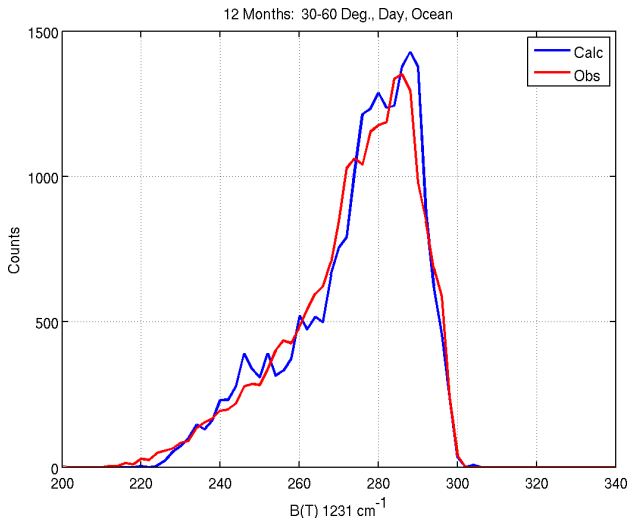
30-60 Deg. Day Ocean

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PDF's for 1231 cm^{-1} , Aug. 2003 - July 2004 30-60 Deg. Night Ocean

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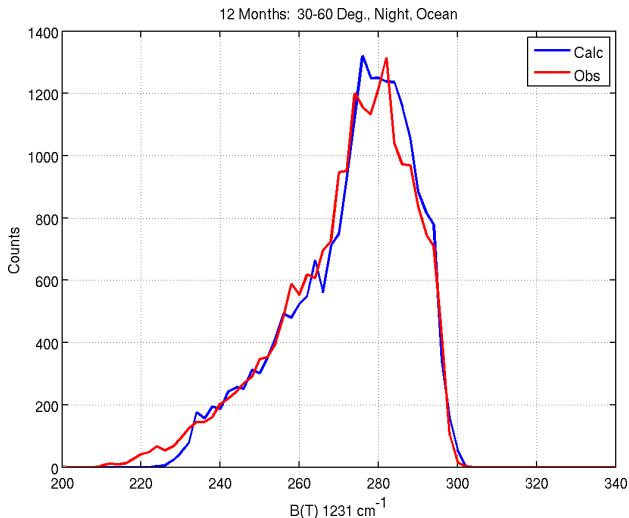
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PDF's for 1231 cm^{-1} , Aug. 2003 - July 2004

30-60 Deg. Day Land

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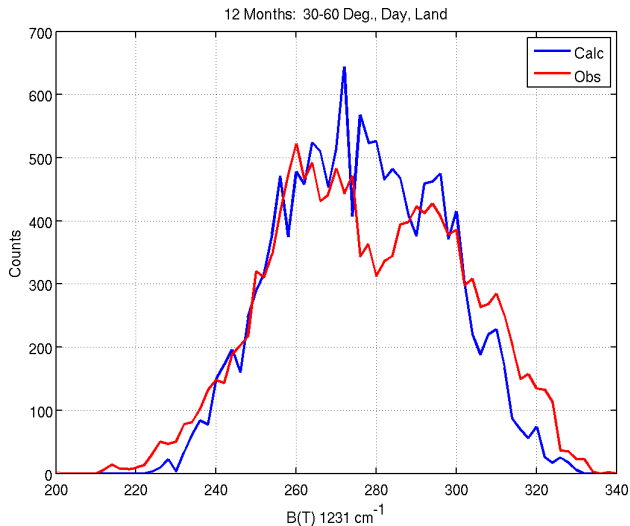
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PDF's for 1231 cm^{-1} , Aug. 2003 - July 2004

30-60 Deg. Night Land

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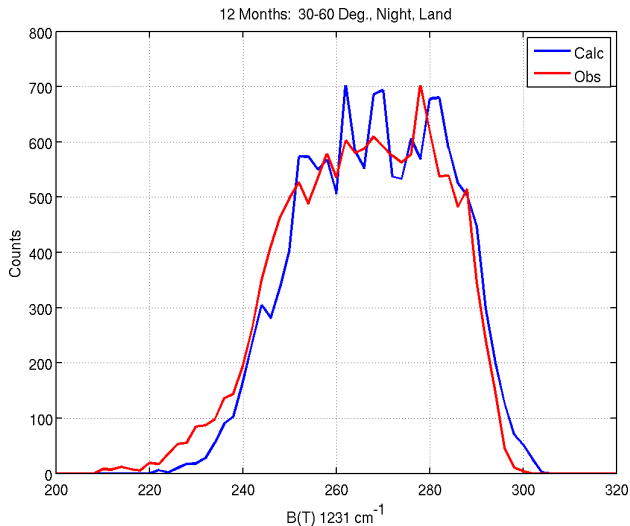
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PDF's for 1231 - 822 cm^{-1} 0-30 Deg. Night Ocean

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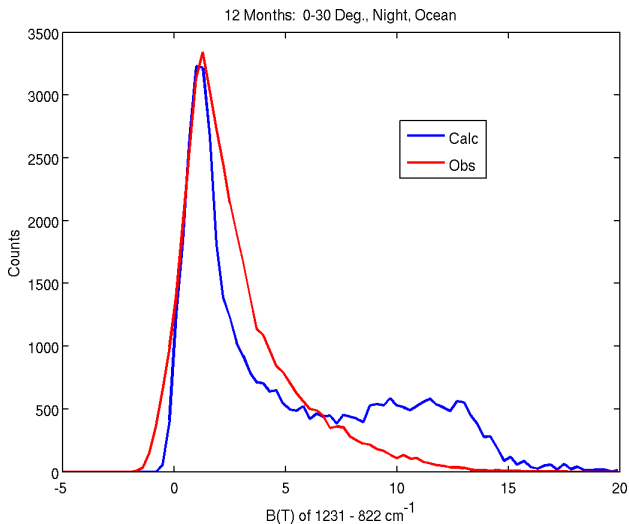
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1231 cm^{-1} Bias vs B(T) of 1231 Channel 0 to 30 Deg. Lat, Day/Ocean, 12 Months ACDS

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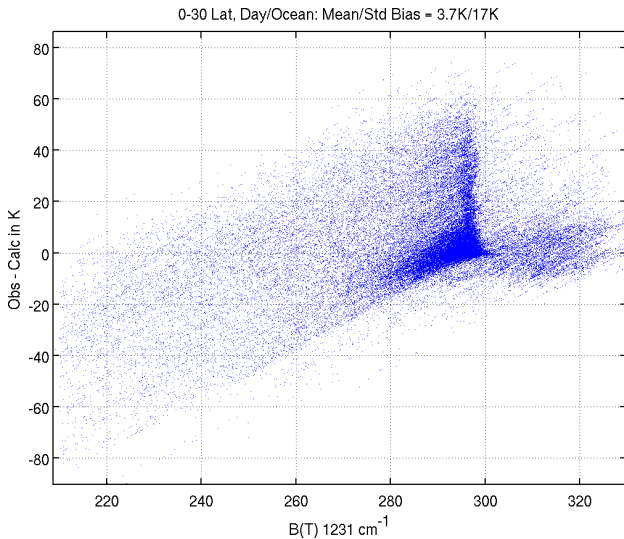
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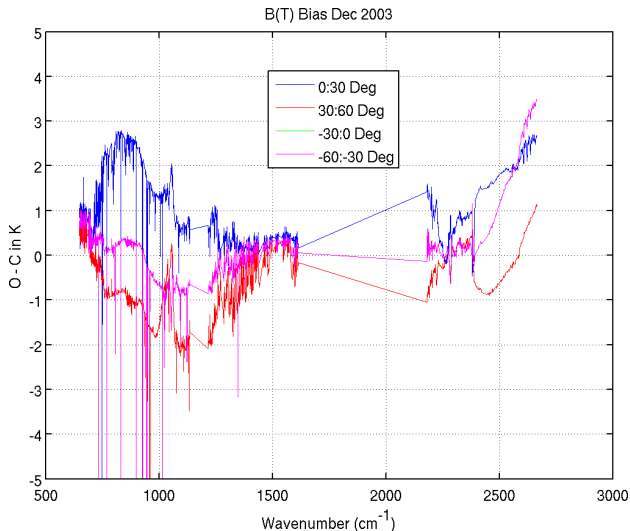


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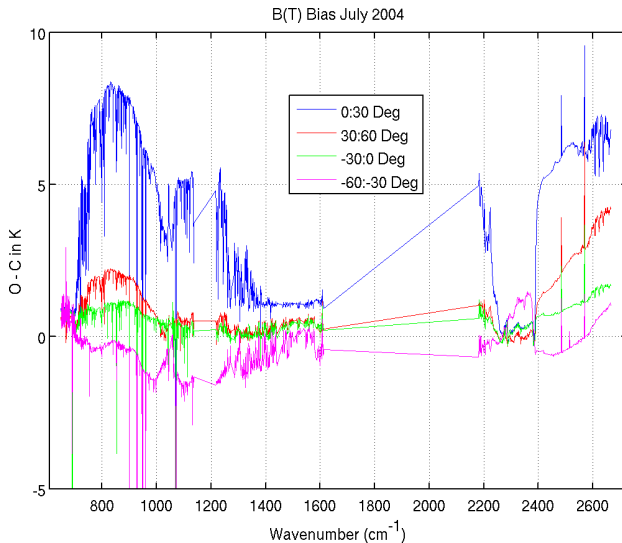
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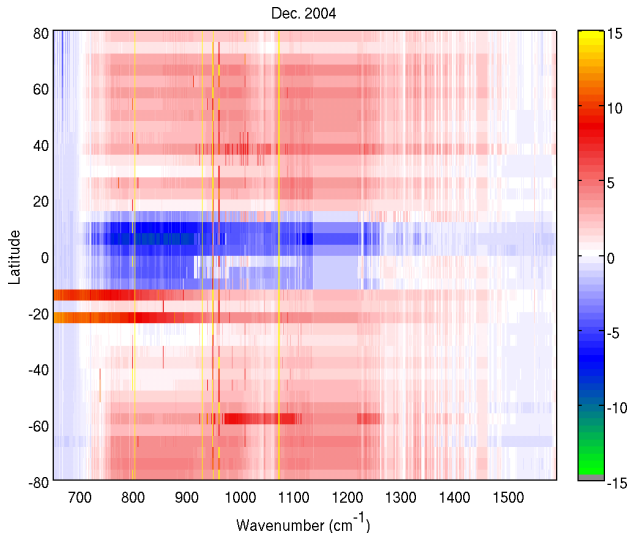


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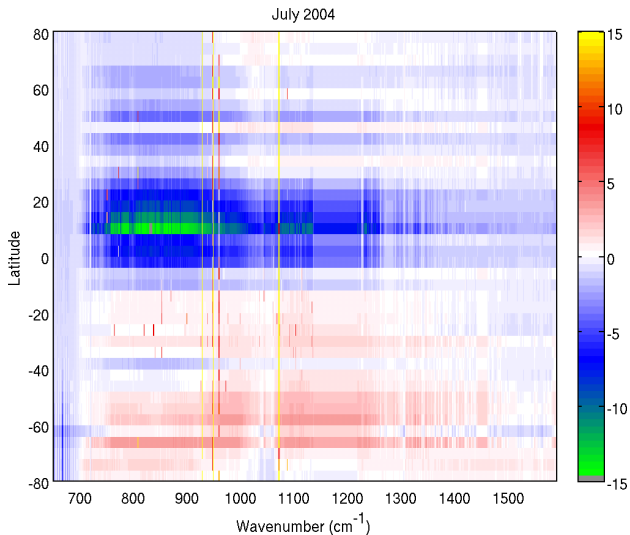
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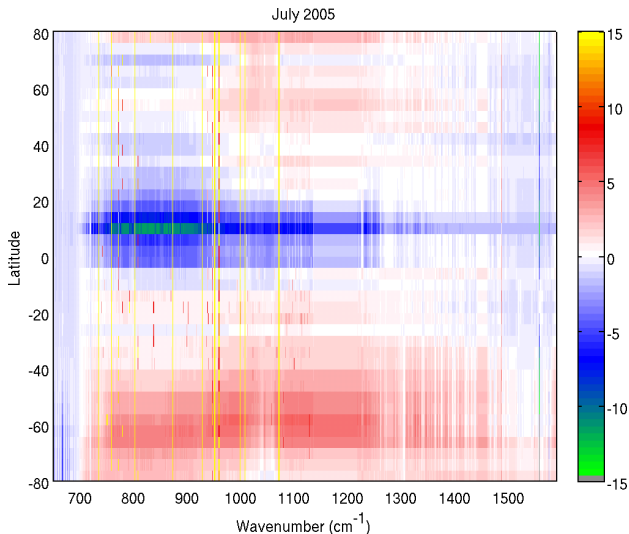


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CM2 and ECMWF 1231 cm^{-1} Time Series

Left: CM2, Right: Obs and ECMWF

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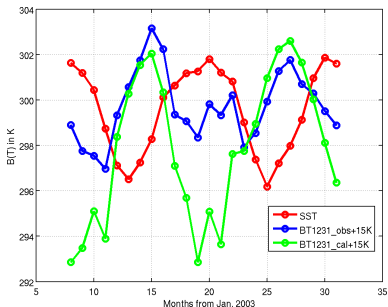
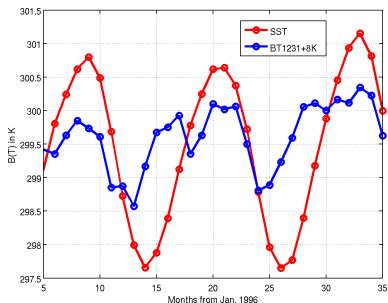
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Results for 0-30 Deg. Latitude

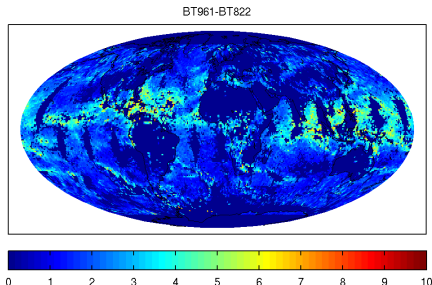


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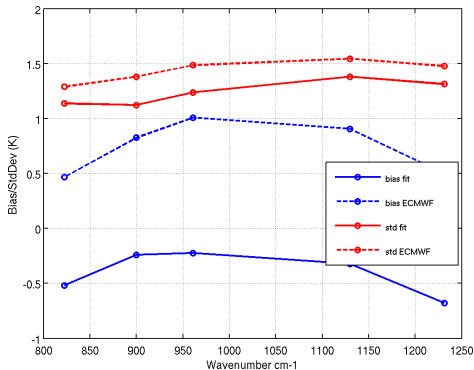
- Retrieval tests underway
- Fix water cloud with AIRS L2, fit for ice amount and effective size at portion of AIRS L2 upper cloud (eventually fix thickness with Calipso (nadir?))
- Baran's ice hex scattering paramss ($Deff = 12.9$ to $143 \mu m$)
- Working on channels and weights, include lower particle sizes
- Figure is just btobs961 - btobs822.

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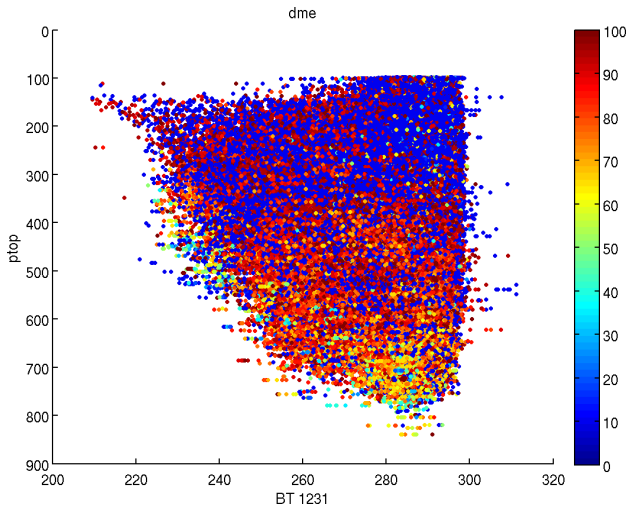
- Particle size limited to **dme between 15 and 70 um**;
- ECMWF means used ECMWF for fixed water cloud. Solid curve used AIRS L2 retrieval for fixed water cloud.

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- Scattering RTA reproduces much of the behavior of the observed PDF's for BT 1231 cm^{-1} .
- More work need to validate scattering codes: comparisons with other, more accurate codes
- Cirrus cloud retrievals can remove closure biases
- V6: cirrus retrivals?